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# IceCube: CubeSat Demonstration of 883-GHz Cloud Ice Radiometer

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## Overview

### Objective

- Develop and validate a commercially available flight-qualified 883-GHz receiver to enable accurate cloud ice measurements from space
- Raise the instrument TRL (from 5 to 7) to reduce risks of ice cloud imaging radiometers for the Decadal-Survey mission (e.g. ACE)

### Technology

- GSFC heritage of the airborne ice cloud instrument, Compact Scanning Submillimeter-wave Imaging Radiometer (CoSIR), successfully flown in 2007
- 883-GHz receiver from VDI high performance frequency extension of vector network analyzers with accuracy < 2 K and precision < 0.2 K
- Noise injection and Local Oscillator (LO) power modulation for intermediate frequency (IF) calibration + Spinning CubeSat for monitoring absolute radiometric calibration

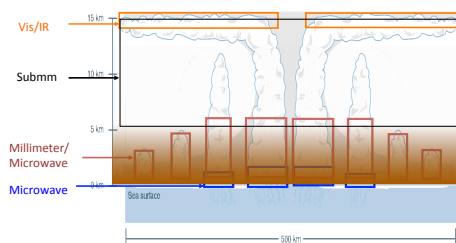
### Approach

- GSFC/Greenbelt design and I&T of 874-GHz VDI receiver
- GSFC/WFF design and I&T of 3U COTS-component CubeSat
- Launch to and release from ISS for 28+ days science operation
- Spinning CubeSat around the sun vector for periodic 883-GHz radiometer calibration
- High-performance CubeSat power and thermal controls

### Partnership

- Virginia Diodes, Inc. (VDI)

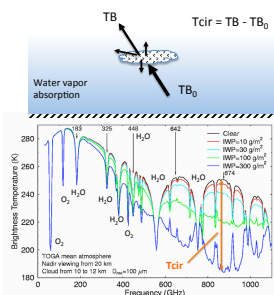
## Needs of Submillimeter-Wave Radiometry for Cloud Ice Measurements



- Cloud as the leading source of uncertainties in climate change prediction
- Cloud ice differences as large as 2x - 10x among observations or models
- Key gap in cloud observational constraints for model development
- Needs for accurate (25%) cloud ice and microphysical property measurements

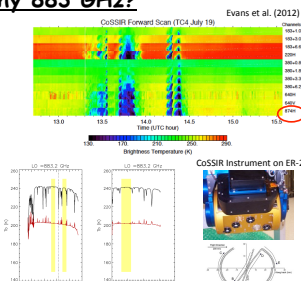
## Ice Cloud Scattering Properties at Submm

- Higher sensitivity to cloud scattering at submm-wave
- Cloud-induced radiance,  $T_{clr}$ , proportional to cloud ice water path (CIWP)
- Cloud microphysical properties (i.e., particle size) from different frequencies
- Simultaneous retrievals with  $T$ ,  $H_2O$



## Why 883 GHz?

- Clean spectral window with minimum absorption from major gas molecules  $O_2$ ,  $H_2O$ ,  $O_3$ ,  $NH_3$  and  $O^{18}O$
- Good sensitivity to low cloud ice and small-size ice particles
- Compact and mature receiver technology
- Day-night measurements

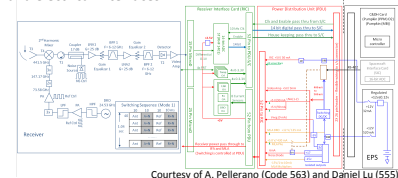


## Instrument

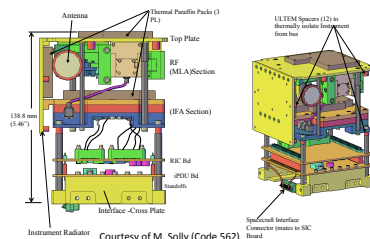
### Key Subsystems

- Mixer LO Assembly (MLA)
- Intermediate Frequency Assembly (IFA)
- Receiver Interface Card (RIC)
- Power Distribution Unit (PDU)
- Instrument mechanical structure

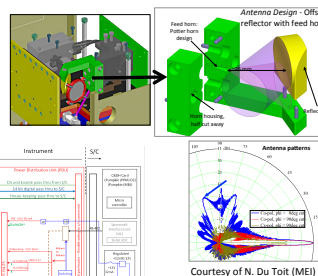
### Instrument system block diagram and electrical interfaces



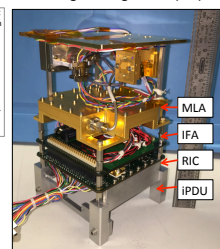
### Instrument Mechanical Structure



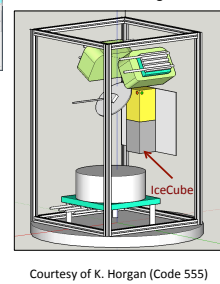
### 883-GHz Antenna



### Engineering Model (EM)

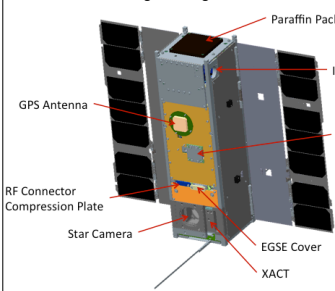


### Instrument EM and flight I&T

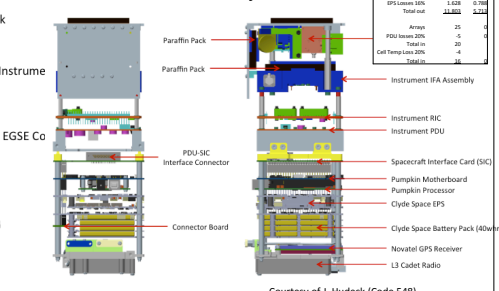


## Spacecraft

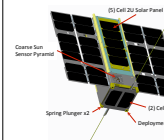
### IceCube Flight Configuration



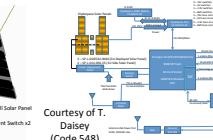
### Internal Layout



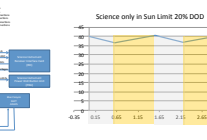
### External Layout



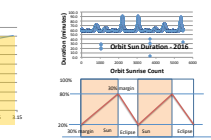
### C&D Interface



### Power Management

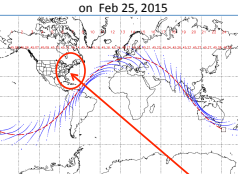


### Thermal Management

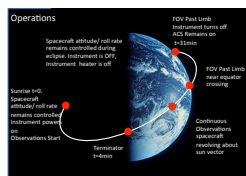
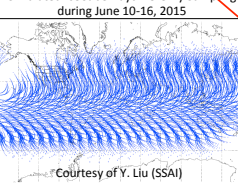


## Operation Concept

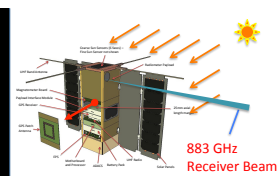
### Simulated IceCube Sampling for ISS Orbits on Feb 25, 2015



### Simulated IceCube Daytime-Only Sampling during June 10-16, 2015



Ground Communications and Data System at WFF  
Courtesy of R. Stancil (Code 589)



## Project Schedule Update

Project start	4/14/14
System Requirements Review (SRR)	7/29/14
Table Top Design Review	10/23/14
Critical Design Review (CDR)	4/28/15
Instr. Integration & Test begins	9/16/15
Pre-Environmental test Review (PER)	2/12/16
Pre-Ship Review (PSR)	4/12/16
Flight Readiness Review (FRR)	1/14/16
LRD	6/10/16